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HOSPITAL LAUNDRY STANDARDS AND ENERGY CONSERVATION: A PROGRAM PLAN

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Hospital Laundry Standards and Energy Conservation

A Program Plan

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Introduction

Energy conservation practices have generally not been widespread among hospitals. The traditional view has been that patients deserve the best care possible, and that the cost of such care is of secondary importance. In these days of rapidly escalating fuel prices, such a viewpoint deserves deeper scrutiny.

Hospitals are one of the larger users of energy in the commercial sector. Figures for 1970 show that hospitals used an estimated 0.379 quadrillion BTUs or 9.76% of the 3.885 quads used in the commercial sector. Another estimate shows a use of 0.937 quads, or 11.72% of the commercial sector's total of 7.995 quads (from information cited in Hittman report). Thus, it seems that energy conservation in the hospital could have a sizeable impact on the nation's fuel consumption.

Hot water heating can account for a large fraction of a hospital's energy use. Hittman associates (1979), in their summary report on water use in hospitals show that from 6 to 19.3% of the total energy used in the hospital is due to heating water.

The single largest user of hot water in the hospital is the hospital laundry. Data presented in the Hittman report show that the laundry, in hospitals so equipped, can account for 50 to 75% of the total hot water used. This corresponds to 10 to 15% of the total energy used throughout the hospital. In terms of conservation of energy, energy savings effected in the laundry could amount to a sizeable reduction in total energy use. The single most effective step for decreasing hot water use would be the use of lower temperature water than is currently used in the laundry. However, this cannot be done as a matter of choice by the laundry manager. Various standards dictate the water temperatures that must be used in the laundry cycle. These standards have been established by the Department of Health, Education, and Welfare, and by state health department codes. It can be seen that hospital laundry services have little choice in the area of hot water use.

The standards as they currently exist are apparently based on the results of research published by Arnold in 1938. Arnold's work is still considered to be one of the most thorough studies of laundry water temperature and its effect on microorganisms. His data, based on a one year study of two laundries, show that temperatures above 165^{o}F, used in the suds and rinse cycles, along with the use of a sour in the last cycle yield a virtually "sterile" product. These data are used to support the guidelines given in the Hospital Laundry Manual of Operation (1949).

The newly revised "Minimum Requirements of Construction and Equipment for Hospital and Medical Facilities" (DHEW report # (HRA)79-14500) dictates that the temperature must be 160^{o}F, a decrease from the previous requirement of 180^{o}F. This is the first time in the twenty years since these requirements first became law that this standard has been changed. In those states that have codes for minimum laundry temperatures, the codes are essentially those of DHEW. Many states have no specified requirements. These states presumably still follow the standards of DHEW. The Hittman report surveyed the literature to find further justification for these standards. Their conclusions were that the evidence published to date was too contradictory and inconclusive to support or refute the 160^{o}F temperature. Their major finding was the need for a research program to perform the following:

> Development of a universally accepted method for determining contamination levels in finished hospital laundry products. The developed methodology should specify the contaminant or contaminants to be identified in the hospital laundering

cycle, the associated maximum acceptable contamination levels, and the laboratory testing techniques to be used in the identification process. One approach to establishing the above elements of the standardized method is to convene a panel of experts in the technology areas involved and extract from this body the required guidelines. A second approach could be the submitting of a questionnaire to a relatively large cross section of scientists in the involved technology areas and from the responses received develop a consensus standardized methodology.

Development of an accepted time-temperature-chemical standard to insure the hygienic and aesthetic cleanliness of hospital laundered products. This standard should be developed such that it is easily complied with and enforced. The research effort designed to develop this standard should begin with a parametric laboratory study of the key variables. Once the more promising methods of approach have been identified, these methods should be thoroughly tested to insure repeatability and accuracy. Furthermore, this research effort should be sufficiently extensive to include the total hospital laundry process, i.e., from linen pickup to end use delivery."

This project was undertaken to produce a program plan describing required research and experimental plans for establishing a proposed revision of hospital laundry standards. An extension of the literature search done by Hittman and Associates was done to see whether the quality of the finished laundry could be maintained under revised standards. Consideration was given to the following factors:

1) Stain removal. Stains such as blood, fecal material, and other exudates present a special cleaning problem, and need certain conditions to be removed.

2) Whiteness. Soiling of linen and redeposition of soil during laundering can make linens grayish or yellow in appearance. Adequate removal and suspension of soil particles by detergent action, along with the effect of bleach are critical to insure the whiteness of the finished product.

3) Sanitation. Linens can serve as reservoirs of pathogenic organisms. The laundering process depends on the interaction of several factors to destroy these organisms. Temperature, bleach, pH, germicides,

and detergents are important in bringing about the destruction of microorganisms on linen.

Of these three factors, the last is the most important from a public health standpoint. However, the other two cannot be ignored and dismissed as unimportant. The appearance of the linen in the hospital is the only thing patients or staff can see. With the price of hospital care as high as it is, patients, as the consumers, are entitled to feel that their bed linens should be clean in appearance. Any change in laundry formulae cannot be based solely on sanitation aspects, but on aesthetic qualities as well.

Technical Considerations

Some effort was made to ascertain the effect of washing at lower temperatures on stain removal and whiteness. Further information can be obtained from the technical literature, or from consultation with laundry supply manufacturers that might have access to research results.

Stain Removal

The most commonly encountered stains in the hospital laundry are blood, fecal material, and other bodily exudates. Since these stains are mostly protein in nature, the use of high temperatures can denature the protein, and without detergent, possibly set the stain, making removal quite difficult (Becker, 1978). The use of an initial lukewarm flush can be successful in removing blood and fecal stains. If high temperatures are to be used initially, the addition of alkali and detergent simultaneously with the water is critical (Hosp. Laundry Manual, 1949). The use of 160°F, or hotter, water is not necessary, and generally is not recommended. These stains are adequately removed at temperatures much lower than 160°F.

Greasy stains may occasionally need temperatures hotter than 160°F for removal; these temperatures may sometimes approach 180°F. Such greasy or oil stains would not be removed in most hospital laundries following existing standards. However, grease or oil based stains are not encountered frequently in hospital linen. For those stained linens that will not come clean in a standard process, special treatment would be a better choice than overwashing all linens to clean only a few difficult items adequately.

Most other stains that might be encountered in hospital linen can be adequately removed in a normal washing process that includes bleach at a temperature between 140° and 160°F (Spillard,1964). In most cases, the initial flushing of stained materials is more important than the detergent action in the washing cycle (Addison, pers. comm.).

Detergent action and cleanliness

To insure that hospital linens become clean and retain their whiteness, detergent action is necessary to remove the soil from fabrics, and must be able to keep the soil particles in suspension to avoid redeposition back on the fabric. This redeposition of soil particles is responsible for the loss in whiteness of fabrics. An efficient detergent is capable of removing bound soil and of keeping it in suspension.

The temperature at which detergents or soaps become effective depends on the type of product used. The detergent industry has provided the home laundry user with products that function well in cold water. Hospital and commercial laundries must use hotter water to clean more heavily soiled clothes as well as to provide sufficient sanitation effects. Consequently, the soaps used at the higher temperatures are designed to work in the hotter water. Medium titre soaps are generally used in the hospital laundry. These are made to dissolve at temperatures of approximately

130° to 140°F. Dissolution of the soaps is necessary to bring about a cleansing effect. The medium titre soaps of at least one manufacturer are formulated to reach saturation of detergent action at 160°F. The recommended working range for these soaps is 140° to 155°F, with an optimum of 150°F. Use of this temperature is to insure maximum soil removal and suspension of soil in the wash. In the case of hospital linens, which are usually not very heavily soiled or stained, a temperature slightly less than the optimum should still provide adequate results. In terms of added cleansing effect, use of water hotter than the optimum is only wasteful. For example, Loeb and Pollard (1970) have shown that the amount of soil removal with detergent used in 120°F was not significantly increased at 150°F. They were also able to show that the increased temperature resulted in a greater loss of tensile strength of the fabric. Another study shows that 120°F was much better for soil removal than 100°F, for all types of detergents tested. 140°F was better than 120°F, but the difference was much less than that noted between 100°F and 120°F. Data at any higher temperatures were not presented.

From these observations, it appears that a decrease of ten or twenty degrees in water temperature used in the laundry would not have a detrimental effect on detergent action in soil removal.

Bleach is another important factor in the cleansing of hospital linens. In addition to its bactericidal effects, bleach is necessary to remove some stains, and to whiten fabrics. The amount of bleaching action depends on time, concentration, and temperature. Adequate bleaching can be achieved in 5 to 10 minutes at 160°F for most purposes. Higher concentrations of bleach can decrease the time requirements, but care must be taken not to raise concentrations to excessive levels because of the damage to fabrics that can result. At 140°F, bleaching action begins to speed up as temperature is increased. Temperatures over 160°F do not add any additional bleaching effect and can harm vegetable based fibers. A decrease in temperature from 160°F to 140°F can be expected to increase the time necessary for stain removal. Just how much of an increase depends on bleach concentration, the pH, and the nature of the stain. Most bleaches are capable of providing adequate results at temperatures below 160°F; increases in time and/or concentration may be used to compensate for the small loss of bleaching action speed at lower temperatures.

It seems that the use of a temperature as low as 140° on the laundry would not prevent adequate cleaning of hospital linens. Minor changes in laundry formulas may or may not be required to produce the desired effect. Tables 1 through 5, reproduced from the Hittman report, show that a temperature of 140°F can produce good results and that hotter temperatures probably are not necessary for adequate cleansing of most linens.

Microbial Loading

No evidence of transmission of disease by laundered hospital linens has been found in the literature to date. This does not preclude the necessity for achieving a product that is bacteriologically safe for the patients that use them. It has been shown that various organisms, including *Staphylococcus aureus*, polio virus, vaccinia virus, and *Salmonella typhimurium*, can persist on fabrics for days to weeks after contamination occurs (Sidwell et al 1966, Wilkoff et al 1969, a & b). The possibility of infection resulting from contact with linens that have become contaminated, or that have not been completely decontaminated

TABLE 1. CALIFORNIA STUDY OF COLD WATER EFFECTIVENESS IN HOSPITAL LAUNDRY FORMULAS - LOAD B

LOAD B DATE 12-10-78

KIND OF WORK	DEGREE OF SOIL	DRY WEIGHT
DRY FOLD	MED -HEAVY	310 LBS.

SIZE AND TYPE OF WASHER MILNOR WX 450

	OPERATION	Temp.	Time Min.	Water Inches	Titration	pH Value	SUPPLIES Kind	SUPPLIES Amount
1	FLUSH	110	2	16				
2	BREAK	110	6	6		10.5	BUILT DETERGENT	2 lbs
3	BLEACH	110	6	6		9.5	SODIUM HYPOCHLORITE	16 oz
4	RINSE EX	110	1	16		7.5		
5	EXTRACT		1/2					
6	RINSE	cold 70	1	16				
7	SOUR/SOFT	70 cold	5	6			SOUR ANTI CHLOR SOFTNER	6 oz 8 oz
8								
9								
10	STAIN INCIDENT VERY HIGH --UNREMOVED FECES --ODOR OKAY--COLOR OKAY							
11								
12								
13								
14								

WATER HARDNESS 0

AVAILABLE CHLORINE BLEACH SOLUTION 12%

TABLE 2. CALIFORNIA STUDY OF COLD WATER EFFECTIVENESS IN HOSPITAL LAUNDRY FORMULAS - LOAD C

LOAD C DATE 12-11-78

KIND OF WORK	DEGREE OF SOIL	DRY WEIGHT
DRY FOLD	MED - HEAVY	310 LBS.

SIZE AND TYPE OF WASHER MILNOR WZ 400

	OPERATION	Temp.	Time Min.	Water Inches	Titration	pH Value	SUPPLIES Kind	SUPPLIES Amount
1	FLUSH	110	2	16				
2	BREAK	120	6	6		10.5	BUILT DETERGENT	2 lbs
3	BLEACH	120	6	6		10.	BLEACH	16 oz
4	EXTRACT		1/2					
5	RINSE	100	2	16				
6	EXTRACT		1/2					
7	RINSE	cold	2	16				
8	SOUR	cold	4	6		6.	SOUR SOFTNER	6 oz 8 oz
9								
10								
11								
12	INCREASED SUPPLIES-IMPROVED 120° load over lower supplies, however stain							
13	incident heavier than the 130° break and 140° bleach. This load based on 160° saved 30° on the break and 20° on bleach with incoming water 60°							
14								

WATER HARDNESS 0

AVAILABLE CHLORINE BLEACH SOLUTION 12%

Titration 0.0 active
0.3 inactive

TABLE 3. CALIFORNIA STUDY OF COLD WATER EFFECTIVENESS IN HOSPITAL LAUNDRY FORMULAS - LOAD D

LOAD D DATE 12-11-78

KIND OF WORK	DEGREE OF SOIL	DRY WEIGHT
DRY FOLD	MED -HEAVY	310 LBS.

SIZE AND TYPE OF WASHER MILNOR WX 450

	OPERATION	Temp.	Time Min.	Water Inches	Titration	pH Value	SUPPLIES Kind	SUPPLIES Amount
1	FLUSH	100	2	16				
2	BREAK	130	6	6		10.5	BUILT DETERGENT	1 lb
3	BLEACH	125	6	6		10	SODIUM HYPOCHLORITE	16 oz
4	EXTRACT		1/2					
5	RINSE	125	1	16				
6	EXTRACT		1/2					
7	RINSE	COLD	1	16				
8	SOUR	COLD	4	6		6	SOUR SOFTNER	6 oz 8 oz
9								
10								
11	HIGH STAIN INCIDENT SOME UNREMOVED FECAL MATTER -ODOR OKAY-COLOR OKAY							
12								
13								
14								

WATER HARDNESS 0

AVAILABLE CHLORINE BLEACH SOLUTION 12%

Titration 0.0 active
0.3 inactive

TABLE 4. CALIFORNIA STUDY OF COLD WATER EFFECTIVENESS IN HOSPITAL LAUNDRY FORMULAS - LOAD E

LOAD E DATE 12-11-78

KIND OF WORK	DEGREE OF SOIL	DRY WEIGHT
DRY FOLD	MED -HEAVY	310 LBS.

SIZE AND TYPE OF WASHER MILNOR WX 400

	OPERATION	Temp.	Time Min.	Water Inches	Titration	pH Value	SUPPLIES Kind	SUPPLIES Amount
1	FLUSH	105		16				
2	BREAK	130		6		10.5	BUILT DETERGENT	2 lbs
3	BLEACH	140		6		10	BLEACH	16 oz
4	EXTRACT							
5	RINSE	140		16				
6	EXTRACT							
7	RINSE	COLD		16		6		
8	SOUR						SOUR SOFTNER	6 oz 8 oz
9								
10	GOOD RESULTS AT BREAK 130° and BLEACH 140° on THIS DRY FOLD LOAD							
11								
12								
13								
14								

WATER HARDNESS 0

AVAILABLE CHLORINE BLEACH SOLUTION 12%

Titration 0.0 active
0.3 inactive

TABLE 5. CALIFORNIA STUDY OF COLD WATER EFFECTIVENESS IN HOSPITAL LAUNDRY FORMULAS - LOAD F

LOAD F DATE 12-11-78

KIND OF WORK	DEGREE OF SOIL	DRY WEIGHT
SHEETS-THERMALS FLATWORK	MEDIUM -LIGHT	310 LBS.

SIZE AND TYPE OF WASHER MILNOR WX 450

	OPERATION	Temp.	Time Min.	Water Inches	Titration	pH Value	SUPPLIES Kind	SUPPLIES Amount
1	FLUSH	COLD	2	16		10.5		
2	BREAK	130	6	6		10.	BUILT DETERGENT	2 lbs
3	BLEACH	130	6	6		9.	BLEACH	
4	RINSE	130	2	16				
5	EXTRACT		1/2					
6	RINSE	COLD	2	16		7.5		
7	SOUR		4	6			SOUR	6 oz 8 oz
8								
9								
10	SATISFACTORY RESULTS ON FLAT SHEETS AT 130°							
11	NOTE LIGHT SOIL							
12								
13								
14								

WATER HARDNESS 0

AVAILABLE CHLORINE BLEACH SOLUTION 12%

Titration 0.0 active
0.3 inactive

does exist. One must therefore strive for linens that are microbially safe. Much attention has been focused on the methods and conditions necessary to insure that laundered items do not become a source of infection. Temperature, bleaches, and germicides are just some of the factors that have received the most attention.

In 1926, Guernsey published a short paper on the effects of heat on detergency and sanitation in laundering. This report is mainly anecdotal, but it does discuss the need for heat in soil removal and sanitation in laundering. Guernsey points out that in addition to heat, the major germicidal agents in washing are chlorine bleach, mechanical action for bacterial removal, and the bactericidal effect of soap. However, no data are given to support these statements.

One of the earliest reports in the literature to present data on contamination levels in laundered linen is that of Arnold (1938). This work appears to be the basis for the standards as they are written today. The study was based on a year-long survey of 54 laundry facilities. In two of these facilities, Arnold examined the bacterial counts in the water at various parts of the wash cycle, as well as counts on textiles processed through the cycle. Arnold was able to show that the use of a formula which includes 165°F water in the final suds for fifteen minutes, then in each of the four rinses, and then the addition of a sour at the end of the cycle, produced bacteria-free water in the washer. The low temperature cycle used for colored fabrics (maximum temperature was 100°F) depended on dilution of the bacteria for removal, along with the use of a sour in the last step. Even then bacterial counts were much higher than for white fabrics washed at the high temperature. The predominant organism found was *Staphylococcus albus*. No data are given for any temperatures between 100°F and 165°F. Ironing of fabrics washed at both temperatures was capable of killing large numbers of seeded bacteria, including several species of Bacillus, Streptococus and Staphylococcus. Ironed fabrics were virtually bacteria free. Contamination in calcium deposits on the wooden cylinders could lead to contamination of fabrics later washed at the low temperatures. The hot water cycle was shown to be capable of decontaminating the cylinders, and thus prevent later contamination of fabrics. Although wooden cylinders are no longer used, the washer itself can still be a source of contamination for later wash loads. (Buford et al, 1977) Arnold's data are summarized in Table 6.

Since Arnold's data were published, surprisingly little work has been done concerning water temperatures used in the hospital laundry situation. There appears to be a paucity of new data published after Arnold's work, until Ridenour published the results of a study on sanitation in self service washers in 1952. However, during this time span, the "General Standards for Construction and Equipment" for hospitals and health care facilities were published in the Federal Register. These standards, put into effect in 1947, dictate a water temperature of 180°F for the hospital laundry. The choice of this temperature seems to be a conservative extension of the results of Arnold, considering that little other information was available at the time. The recommendations in the Hospital Laundry Manual of Operation follow this conservative approach. The manual suggests the use of 160°F to 180°F water for 25 or more minutes, depending on the degree of soiling. The evidence given to support these recommendations is in Arnold's work.

The Department of Health, Education and Welfare (DHEW) maintained these standards unchanged until 1979. In 1979, DHEW published its new standards for minimum construction requirements for hospitals and health care facilities. These standards establish a temperature of 160°F to be used in the hospital laundry:

> Required temperature of 160°F (71°C) in the laundry is that measured in the washing machine and shall be supplied so that temperature <u>may</u> be maintained over the entire wash and rinse period. Attention is called to the fact that control of bacteria in laundry processing is dependent upon a number of interrelated factors such as detergent, bleach, number of rinses and temperature. In most instances, maximum overall economies with acceptable results can be achieved with the use of 160°F (71°C) water. Lesser temperature may require excessive bleaching or other chemical treatment that would be damaging to fabrics.

No literature is given to reference this standard.

Table 6. Summary of Arnold's data (1938).

HOT CYCLE

	Temperature	Time (min)	Bacterial counts per ml wash water
Flush	110°F	5	200,428
Suds 1	125°F	10	94,314
2	135°F	10	42,518
3	140°F	10	8,382
4 (+ bleach)	165-170°F	15	5
Rinse 1	165°F	3	1
2	165°F	3	0.5
3	165°F	3	0.4
4	165°F	3	0.2
After sour	140°F	10	Sterile
Blue	110°F		

COLD CYCLE

	Temperature	Time (min)	Bacterial counts per ml wash water	Bacterial counts per in^2 on fabrics
Flush	90-100°F	5	3,674,055	3,776
Suds 1	100°F	10	1,979,862	813
2	100°F	10	1,248,758	
3	100°F	10	255,579	
4	100°F	10	221,293	
Rinse 1	100°F	3	88,966	201
2	100°F	3	67,461	
3	100°F	3	43,809	
4	100°F	3	35,278	
5	100°F	3	24,441	84
After sour	100°F	5	158	36
After 9 minutes extracting				4
After ironing				0

In the early 1950's, Ridenour conducted a study of several factors on sanitation in self-service washing facilities. He was able to show that in addition to mechanical removal of microorganisms in the washing cycle, heat amd chemical germicides could be effective in destruction of seeded bacteria. Temperatures of 140°F or 150°F for three minutes in a washing cycle resulted in a 99.99% reduction of E. coli and M. pyogenes var. aureus (Staphylococcus aureus), as determined by a swatch rinse method. Hypochlorite solutions and quaternary ammonium salts were also effective in destruction of E. coli and S. aureus. A 96.41% reduction in E. coli and 95.334% reduction in S. aureus was noted when seeded swatches were exposed to 100 ppm sodium hypochlorite at 100°F for 5 minutes, in the presence of soil. Absence of soil increased the amount of bacteria removal, to a 99.99% reduction of both organisms at 10 ppm sodium hypochlorite. Addition of 5 ppm sodium hypochlorite in the final rinse also gave a 99.999% reduction in E. coli and S. aureus. Alkyl dimethyl benzylammonium chloride at 100 ppm gave a 96% reduction in S. aureus when washed at 100°F. None of the treatments tried were effective in destruction or kill of B. cereus spores.

Ridenour also reported some results of preliminary studies on drying and ironing. Using S. aureus as the test organism, seeded swatches showed a 95% reduction in counts when dried at 160°F for 30 minutes. Ironing similarly seeded swatches twice at a cotton setting killed 99.999% of the bacteria. These swatches were not laundered prior to drying or ironing.

Two reports on laundering and temperature effects were published in the Monthly Bulletin of the Ministry of Health in July, 1958. In what amounts to heat tolerance data, Crone showed that without detergents, Staphylococcus aureus could not be recovered from cloth strips after exposure to 141^{o}F water for 5 minutes. Using autoclaved milk as a substitute for soil on linens also artificially contaminated with S. aureus, he showed that 131^{o}F water was necessary for a greater than five log reduction in bacteria in the water. His conclusions were that temperatures below 140^{o}F should not be used if destruction of S. aureus is desired.

In the same issue of the journal, Jerram reported that a temperature of 140^{o}F to 149^{o}F for 14 minutes was effective in completely destroying Streptococcus faecalis var. zymogens, Chromobacterium prodigiosum, and Mycobacterium tuberculosis. Jerram's results are based on impression plate samples of linen surfaces. Initial counts ranged from 7×10^7 to 4.1×10^9 organisms per half inch square of cloth. These data showed no difference between 149°F and 212^{o}F (i.e., at both temperatures, no survivors were noted). At 140°F, 40 S. faecalis organisms/0.5 in^2 were noted on a single occasion. Four other trials at 140°F produced no survivors. Jerram also showed that passing a Staphylococcus sp. inoculated dry sheet through an ironer (at an unspecified temperature) could not destroy the organisms, but that passing a wet sheet inoculated in the same way through the same ironer would produce no survivors on the sheet. In a single trial, drying an inoculated sheet at 194°F for 45 minutes did not appreciably reduce the numbers of organisms on it. Jerram concluded that temperatures of 140-149°F can be as effective at killing microorganisms as the traditional European method of using near-boiling temperatures in the wash. Jerram's results are based on impression plate samples of linen surfaces.

Sandiford, Blowers, and Wallace (1959) looked at the problem of disinfection of hospital linen from a slightly different viewpoint. Using an impression plate method, sluicing (preliminary washing) of babies napkins at temperatures greater than 140°F produced low bacterial colony counts on the fabric. A total of seven bacterial colonies in 24 runs were observed after laundering at temperatures greater than 140°F. At 122°F, 805 colonies in six runs were noted. Those organisms surviving were mainly "streptococci of the fecal type" and aerobic spore-bearers. Treatment with hypochlorite solution (chlorine - 15 ppm) was effective in killing virtually all coliforms and fecal streptococci on the fabric. Spore bearers survived temperatures as high as 167°F, and chlorine concentrations as high 50 ppm, but not chlorine concentrations of 100 ppm at 113°F.

Nicholes reported on bacterial counts found in laundered towels from several commercial laundries in the United States and in Europe (1970). His data showed great variation in counts from different launderies, ranging from counts less than 32 per square inch to counts of millions per square inch on clean linen. Counts were obtained using macerated fabric and subsequent plating. Data from a comparison of chlorine bleach and an oxygen bleach show that the oxygen bleach is more effective at removing or destroying organisms, reducing counts 20-fold compared to the chlorine bleach. However, no other information on the laundry formulae used is given. Nicholes does state that the majority of organisms found, namely gram positive spore formers do not present a public health problem. Nicholes concludes that although this might be the case, clean linen relatively free of bacteria is still a desireable goal.

The type of linen used in the hospital has received some attention as it relates to bacterial contamination. A comparison of no-iron sheets (50% cotton, 50% polyester) with 100% cotton sheets showed that the no-iron sheets washed with chlorine bleach at 100°F produced a contamination level comparable to that found in 100% cotton sheets washed in the traditional manner with 160°F water. (Bradley, 1970). Both groups showed greater than a five log reduction in bacteria after washing. An homogenate method and an impression plate method both showed similarity in sanitation levels achieved. The no-iron sheets were dried in a dryer at 160-165°F before counts were taken. The limited scope of this study prevents any definitive conclusions, but the possibility of reduced temperature washing cannot be ruled out.

Another study on polyester-cotton sheeting was conducted by Wiksell, Pickett, and Hartman (1973). They showed that washing at 135°F produced 4.9 *E. coli* bacteriophage per square centimeter, and no *Serratia marcescens*, determined by rinsing laundered swatches in saline. 154°F washing produced no surviving bacteriophage or *S. marcescens*. Mean initial counts were 25,700 per square centimeter and 155,000 per square centimeter respectively. *S. aureus* counts showed a 4.5 log reduction after washing at 135°F, and a 4.3 log reduction after washing at 154°F. However, counts were still sizeable at 154°F. *Bacillus stearothermophilus* spores were removed primarily by dilution or detergent action; 154°F caused only a 1.71 log reduction in survivors per square centimeter. Drying inoculated samples laundered at 135°F decreased spore counts by 0.44 logs and *S. aureus* counts by 0.55 logs.

The type of detergent used for washing (regular vs. cold water) was found to have a minor effect on the counts of S. aureus. The authors also showed that sterile linens can be contaminated when washed with inoculated sheets.

McNeil and Choper (1962) examined the bacterial load on fabric swatches washed in home-type facilities. With water temperatures from 122°F to 140°F in the wash cycle, a sizeable reduction in numbers of bacteria was noted. When quaternary ammonium compounds were added at the hot water setting, a further reduction was seen. The addition of sodium hypochlorite also showed marked reduction of numbers of bacteria. The data presented in this article show a large degree of variability in numbers. This is presumed to be a result of the lack of strict controls on wash water temperature. The only points that can be made here are that quaternary compounds or sodium hypochlorite are capable of a large degree of disinfecting, and that the use of hot water further enhances this effect.

Walter and Schillinger examined the standards for wash water temperature in the state of Montana and published preliminary results in 1975 of a small-scale study of linen contamination after laundering. The results of this study show that Staphylococcus aureus and Klebsiella pneumoniae are destroyed almost completely with 120°F wash water. These organisms showed a 6.75 and 5.28 log reduction respectively, when seeded swatches were washed at 120°F. At 120°F with the addition of chlorine bleach, a 7.09 log reduction in S. aureus was noted. Drying linens after washing in 120°F reduced S. aureus counts 0.15 logs, to 0.27 (log 10) organisms per square centimeter. Drying linens washed at 120°F with 82 mg Cl per liter reduced S. aureus counts to 0.00, a decrease in 0.67 log units. Laundering normally soiled isolation linen at 100°F, 110°F, and 120°F produced the results in Table 7. Walter and Schillinger propose the use of 140°F water in laundering linens from health care facilities. The use of chlorine bleach is suggested as a measure of extra safety. The authors of this report also suggest that a contamination level of 0.2 microbes ($\log_{10}$) per square centimeter of linen be used as a measure of properly laundered linen. The results of this report strongly suggest the need for further detailed examination of wash water temperatures, drying and ironing, and their effect on bacterial contamination.

Table 7. Bacterial counts ($\log_{10}$) per square centimeter of isolation linen washed at different temperatures. (Walter and Schillinger, 1975)

	100°F	100°F	110°F	110°F	120°F
Before wash:					
range	1.53 to 2.59	1.45 to 3.36	2.36 to 3.36	2.83 to 4.97	0.60 to 1.28
geometric mean	1.85	2.46	2.88	3.98	0.78
After wash :					
range	0.0 to 0.0	0.95 to 1.99	0.0 to 0.0	0.0 to 1.81	0.0 to 0.0
geometric mean	0.0	1.36	0.0	0.6	0.0

A major supplier of on-premise laundry products has conducted extensive studies on temperature effects on microbial loading. Using swatches seeded with Staphylococcus aureus, preliminary results indicate that a temperature of 140°F for five minutes is capable of a greater than five log reduction in the number of viable organisms on the fabric. At 120°F, a three to four log reduction is obtained. A full report of this data is expected to be published in the near future (pers. comm.).

Several reports in the literature concerning the microbial loading of linens have been examined. Many of these are based on small, limited sample sizes. The methods used to measure numbers of bacteria vary from one study to another. Some authors used a fabric maceration or homogenization method, while others used an impression plate method, which is less sensitive and prone to more variation in replicate samples. Still others use a combined rinse and agitation method to suspend the bacteria. The differences in recovery of bacteria from one method to another are great, and can vary with respect to types of organisms recovered. A study on the qualitative and quantitative recovery of bacteria from laundered fabrics was published in 1971 (Wetzler, Quan, and Schatzle). This study examined, in part, the problems associated with impression sampling, and possible wrong conclusions that might be derived from data obtained in this way. The authors state that bacteria in fabric show no predictable regularity in imprinting on Rodac (impression) plates. The best range of recovery of bacteria from impression plates was 0.07 to 0.35 percent of that obtained in "rinse-extract" studies. Multiple replication of the same site may, or may not, lead to increased bacterial recovery. Four specimens tested showed no bacteria when measured using Rodac plates.

These same four samples showed low but viable counts when tested with the rinse extract method. Nicholes (1970) reached similiar conclusions concerning the correlation of data from Rodac plates and data from macerate plate counts. Qualitative analysis of Rodac also suffers from limitations. There is lack of discrimination among bacterial genera or species, and there is uncertainty as to whether any bacteriostatic compounds are solubilized and transferred to the plate. Not all bacteriostatic neutralizers can work in a solid state, as in a plate. One must therefore exercise caution when making conclusions from data using Rodac plates. One must be cognizant of the limitations, and extrapolate carefully from the observed result.

In spite of the limitations of the impression plate method, this method does give a measure of those microorganisms on the surface of the linen most easily transferred by direct contact. This aspect is important in terms of likelihood of transmission of potentially pathogenic organisms to a patient in contact with the linen. Impression plates which show no growth are assumed to indicate a low level of surface contamination, and thus a decreased chance of transfer of organisms by direct contact. Prolonged contact with wet or damp linens may allow transfer of organisms bound more tenaciously to the fabric; for this reason, macerated or homogenized fabric samples present more complete information on microbial loading in fabrics.

Making comparisons of data obtained in different laboratories or laundries is also a difficult task, with its own set of limitations. The important thing to consider in all of the studies reported here is not the absolute number of bacteria, but the relative levels observed in a soiled or seeded product and in the finished product. A universal standard for determining bacterial counts on linen would help eliminate problems such as those cited above.

Sources of Contamination and Recontamination

A good deal of research was done, after Arnold's work was published, on defining the sources of contamination in hospital bedding. Contamination can be residual (failure to remove organisms in the laundry process) or introduced through outside sources (exogenous). Rountree and Armytage (1946) identified hospital blankets as a source of pathogenic bacteria. Consequently, various methods of cleaning and disinfecting blankets were tested. Oil emulsions applied to blankets during the laundry process were found to decrease the amount of bacteria released to the air from blankets (Rountree, 1946). The effectiveness of several germicidal chemicals on blankets was also tested. The use of lissapol-cirrasol (Frisby, 1957), cetyl pyridinium bromide (Rountree, 1946), cetyl tri-methylamine bromide (CTB) (Blowers and Wallace, 1955), quaternary ammonium compounds (Newcastle Regional Hospital Board, 1962) and formaldehyde (Wagg, 1965) all proved to be effective in reducing the microbial load on blankets. Since blankets can transfer bacteria to sheets, cleaning of blankets must be considered as a necessary step to reduce contamination of laundered linen.

Church and Loosli (1953) examined the number of organisms in the air of the laundry, as well as bacterial counts of textiles at different stages of the laundry process. They showed that the washing process was efficient in removing bacteria; however, in the open lid extractor used in the laundries studied, much recontamination did occur on the linen. Ironing of the linen was efficient in reducing the bacterial numbers, but was not as successful as Arnold's work showed (1938). This was attributed partly to the overload of bacteria introduced onto the linen by the extraction process. Church and Loosli were also able to show that dried mucous might act as a protective barrier for organisms and thus protect them from destruction during laundering or ironing. One of the major conclusions of their study was that recontamination of clean linen during extraction or folding could be a source of initiating infections.

Rubbo and others showed in an article published in 1962 that recontamination of hospital bedding occurred within 24 hours of introduction to the wards. Such information, together with Church and Loosli's findings, point strongly to the fact that contamination problems may develop even in laundry that is bacteriologically "clean" at the completion of the wash process. Sanitation concern cannot end at the completion of the wash cycle.

Recontamination of clean laundry can occur at any of several points after the laundering process is completed. To help prevent this post-laundering contaminiation, certain procedures can be followed:

1. Sorting of all linen prior to washing, preferably at the source. This This eliminates the need for post-sorting, and it also can be used to sort out, without unnecessary handling, heavily soiled linen which may require special formulae. Running all laundry through a cycle for heavily soiled linen represents an unnecessary use of energy.

2. Separation of clean and dirty linen areas. Airborne contamination from soiled linens can serve to recontaminate laundry, as Church and Loosli were able to show (1953). A negative pressure ventilation system in the dirty side can help prevent movement of aerosolized materials to the clean linen area (Vesley, 1973).

3. Minimum distances for movement of clean linen can reduce the chance of exposure. Minimum human handling can also reduce exposure. Conveyors to carry laundry from one process to the next can minimize the potential for human recontamination.

4. The use of automatic folding and ironing machines minimizes chances for recontamination.

5. Proper packaging of clean laundry is necessary to avoid recontamination. Carts that are used to transport soiled linen should not be used for clean linen. If the same carts must be used, proper decontamination procedures must be followed.

6. Proper personal hygiene must be enforced. Clean uniforms, the use of hairnets, and frequent handwashing are necessary steps in keeping contamination levels down.

These practices will help to keep laundry clean and free of contamination. As Church and Loosli stated, there is no point to an efficient cleaning process if handling of the cleaned product only serves to recontaminate the linens.

Conclusions

A summary table of effective wash water temperatures on various organisms is presented in Table 8. These figures are gathered from 12 reports published since 1938. The conclusions that can be drawn from this table are that a temperature of 140°F is effective in killing most vegetative organisms, and that 150°F is effective for the rest. The use of chlorine bleach has a profound effect on destruction of organisms. As a part of a laundry formula, it can add to the lethal effect produced by heat. The extremes of pH encountered in a wash cycle have also been cited for producing additional microbial kill (Spillard, 1964; Vesley, 1973). The data presented in Table 8 were gathered using several different methods, with different additives, in both lab and laundry settings, and often were of limited sample size. Despite this variability in methodology and results, no technical or microbiological information was found in this study to prevent a lowering of existing standards below 160°F. There is sufficient data at hand to show that lightly soiled hospital linens from non-isolation areas can be laundered quite adequately at a temperature of 140°F. Investigation is required to determine whether all linens, including isolation linens, could be routinely laundered at this temperature. Table 9 shows the added safety derived from drying and ironing, practices routinely followed in the hospital laundry.

Sorting and handling practices were found to be a potential source of contamination of laundered products. Any possible changes in existing standards must be accompanied by a thorough examination of the practices followed in the laundry. The importance of adequate handling practices has been documented. although often anecdotally, in many reports (e.g., Greene, 1970, Church and Loosli, 1953). This aspect of contamination cannot be overlooked, nor should conservative standards compensate for weaknesses in handling practices.

There is room for energy conservation measures in the hospital laundry; however, energy conservation measures must be accompanied by care and practicality in their implementation.

Table 8: Reduction in counts of microorganisms after washing at various temperatures.

Organism	Wash Temp. (°F)	Time	Log reduction in counts	Source
Unidentified	165°	27 min.	>5[a,b]	Arnold,1938
E. coli T3 phage	154°	c	4.41	Wiksell et al,1973
Serratia marcescens	135°	c	5.19[a]	"
Staphylococcus aureus	135,155°	c	4.5	"
"	77°, 20 ppm Cl	c	>6	cited in Foter,1960
"	140°	5 min.	6.18[a]	Walter & Schillinger,1975
"	140°	5 min.	>5	pers. comm.
"	141°	5 min.	>5	Crone,1958
M. pyogenes var. aureus (S. aureus)	140°	1 min.	4.27	Ridenour,1952
"	100°, 5 ppm Cl	15 min.	>4	"
E. coli	140°	1 min.	4.32	"
"	100°, 100 ppm Cl[d]	5 min.	2.33	"
B. stearothermophilus	154°	c	1.71	Wiksell et al,1973
" spores	160°	15 min.	2.7	Ridenour, 1952
Polio virus	130°	10 min.	(no virus recovered)	Jordan et al,1969
"	110°, 200 ppm Cl	10 min.	"	"
"	129° to 140°	c	>4.6	Sidwell et al,1971
Coliforms	123°, 15 ppm Cl	13 min.	4[a,b]	Sandiford et al,'55
"	140°	13 min.	>6[a,b]	"
Streptococcus faecalis	149°	5 min.	>7	Jerram,1958
Chromobacterium prodigiosum	140°	5 min.	>7	"
Klebsiella pneumoniae	120°	13 min.	5.28	Walter & Schillinger, 1975

[a]Authors report no surviving bacteria

[b]Counts in final rinse water

[c]Time not specified

[d]Not under actual washing conditions; washing E. coli seeded swatches produced 99.99% (4 log) reduction by removal by mechanical action alone.

Table 9: Effectiveness of drying and ironing in destroying bacteria.

A. Drying

Organism	Conditions	Log reduction in counts	Source
E. coli T3 phage	115°F[b] (washed @100°F)	1.69[a]	Wiksell et al 1973
Serratia marcescens	115°F[b] (washed @ 76°F)	3.84[a]	"
S. aureus	115°F[b] (")	3.23	"
"	185°F for 30 min.	a	Spillard, 1964
B. stearothermophilus	115°F[b] (washed @ 76°F)	0.78	Wiksell et al 1973
M. pyogenes (*S. aureus*)	160°F for 30 min.	1.78	Ridenour, 1952
"	151°F for 15 min.	0.70	"
S. aureus	(washed at 100°F)[b]	2.36	Walter & Schill-
Klebsiella pneumoniae	(")[b]	0.59[a]	inger, 1975
Unidentified	180°F for 25 min.	a	Johnston, 1958
Clostridium butyricum	185°F for 30 min.	a	Spillard, 1964
E. coli	"	a	"
Pseudomonas arginosa	"	a	"

B. Ironing

Organism	Conditions	Log reduction in counts	Source
Bacillus subtilis	b	a	Arnold, 1938
B. welchii	b	a	"
B. megatherium	b	a	"
B. coli	b	a	"
B. pyocyanus	b	a	"
Streptococcus sp.	b	a	"
Staphylococcus sp.	b	a	"
M. pyogenes	twice at cotton setting	3.91	Ridenour, 1952
Mainly *S. aureus*	350°F[b]	0.4 to 1.4	Church & Loosli 1953
Unidentified	338°F for 1 min.	a	Johnston, 1958

[a] Authors report no survivors

[b] Details not further specified

Program Plan

The following program plan has been drafted based on the results of a comprehensive literature search, as well as on telephone conversations with authorities on microbial loading in linens. These authorities generally agree that additional research is needed before revisions could be made in current standards, although this opinion is not universal. Not all opinions and ideas elaborated in these conversations are incorporated into the plan. In general, the major points of this plan represent our concept of a consensus among those consulted. It should be emphasized that this final report is not specifically endorsed by any of the persons interviewed.

Formation of Advisory Committee.

This project has considered almost exclusively the information available in the open literature. It was decided to base the recommendations of this study on information that is readily available in scientific publications, and not to rely on data obtained from commercial institutions which could not be readily evaluated for completeness or reliability. Since there is potentially much data available from sources in industry, the laundry equipment, laundry chemicals and linen supply industries should be represented on an advisory committee consisting of authorities on laundry and microbiology. This advisory committee should be formed at the outset of this program and should be made up of representatives from industry, as stated above, as well as from academia, and from state and federal health agencies. This committee should assist in the development of the details of the research program, provide input during the course of the project, obtain and evaluate unpublished results from commercial sources, and help evaluate the results at the completion of the project. Results of any unpublished studies should be collected if at all possible, and evaluated for their relevance to this program.

Acceptance of a Microbial Standard.

A problem that continually arises is the lack of a definition of "acceptable sanitation levels." This definition must be formulated before any change in current standards can take place. The task of formulating a definition should be entrusted to the advisory committee. It is presumed that a final definition would not be possible until the results of additional research are evaluated in their entirety. However, some decisions can be made at the outset of the research program. A consensus of opinion should be reached as to whether a maximum allowable contamination level can, in fact, be identified. The identification of one or two bacteria whose counts should be reduced to zero after laundering would help in establishing a desired endpoint. A maximum allowable contamination level cannot be determined by epidemiological methods; current epidemiological methods do not permit the determination of such a contamination level based on data gathered using human subjects. Therefore, a decision must be made based on the knowledge and opinions of those people who are best informed on the subject of microbial contamination of linens.

As the research program progresses, sufficient information might be produced to change or clarify the term "acceptable sanitation levels." Yet, this problem needs to be addressed at an early stage of the program, and kept in mind throughout the course of the study.

The steps discussed below are considered necessary items if a revision of current standards is to be made.

Acceptance of a Method of Measurement of Contamination Levels.

Several different methods have been employed to measure contamination levels in linens. The methods employed vary widely in sensitivity, reproducibility, and accuracy. The acceptance of one reliable method would facilitate data gathering and comparison, quality control checks, and enforcement, if desired, in the hospital laundry. An early objective of the advisory committee should be to decide on a standard method for measuring contamination in linens, one that could be adopted as a universally accepted method of such measurements.

The National Sanitation Foundation has issued standards for the laundering of cloth toweling (1970). These standards include permissible levels of microorganisms on laundered continuous cloth toweling, and a method for measuring these levels (see appendix). This method could be adopted, with minor modifications, to measure contamination levels in linens.

Needed Additional Research.

(A) Survey of microbial contamination levels following current standard practice (160°F).

It has been assumed by many that the hospital laundry provides a product that is virtually free of bacteria. As a result, little information exists on the levels of bacteria actually found on laundered linens. This information would be helpful in establishing a reference level that could be compared to levels measured in fabrics washed at temperatures lower than 160°F. This information would be necessary if a standard or a recommendation concerning maximum contamination level were established.

Objective: To determine what typical levels of contamination are in hospital linens as they are laundered with present procedures. Levels should be measured on the finished product, as well as at representative steps during the laundering process.

Task: This objective could be accomplished by liberal sampling of linens washed in various hospital laundries. Samples should be obtained and checked for contamination using the method chosen to meet that objective above. Enough samples from each hospital laundry would be needed to make statistical analysis possible. Samples should be obtained from more than one hospital laundry to insure that the measurements obtained are representative. The laundry formulae used for laundering the linens should be recorded to enable correlation of results. Samples should be obtained from linens prior to washing, immediately after washing, after drying, and just prior to delivery, to determine whether further microbial destruction or recontamination occurs after the washing cycle. The results of these experiments can then be used as a basis for comparison with modified laundry formulae to be tested in later experiments.

(D) Effect of varying wash cycle conditions on microbial contamination level.

One of the reasons for using 160°F water in the hospital laundry is to destroy microorganisms on fabrics. Other wash cycle conditions might also be capable of adequate microbial destruction. Tests should be conducted from 120°F to 160°F at ten degree intervals while holding other variables constant so that the relationship between wash water temperature and microorganism counts on fabrics can be defined. This relationship is critical if changes in current standards are to be suggested. Similar tests while changing other wash cycle conditions may demonstrate which conditions can provide acceptable sanitation levels.

Objective: To determine contamination levels in linens washed under various conditions. Variables that need to be examined are: temperature, holding time, bleach concentration, and perhaps type of detergent and bleach. Contamination levels should be measured on normally soiled linens and on linens seeded with target organisms. The use of linens or linen swatches seeded with known numbers of organisms is necessary to quantitatively estimate the amount of microbial destruction achieved under different washing conditions. An estimate of energy use should be performed for each set of conditions tested.

1) Tests using specified test organisms

Task: This task can be accomplished in two stages. The first stage should examine swatches seeded with test organisms. Suggested organisms are Pseudomonas aeruginosa and Staphylococcus aureus. These organisms are recommended because of their known resistance to destruction, and the possibility of serious infections from them. The seeded swatches should be laundered in laundry cycles similar to those commonly used, with changes initially in one variable at a time. Contamination levels should be measured immediately after washing. Variables tested should be: time at the hottest temperature (10, 15, 20, 25 minutes); hottest temperature attained (120, 130, 140, 150, 160°F); bleach concentration (25, 50, 100, 200 ppm Chlorine); perhaps detergent type (ionic, nonionic); and chemical additives (e.g., tri-n-butyltin oxide, quaternary carriers). Any chemical additives that have shown possible human toxicity should be excluded. The size of the load must be carefully controlled in all experiments.

It is strongly suggested that these trials be conducted in a facility comparable to a hospital laundry. Equipment and machines could be leased or borrowed from a commercial manufacturer; this approach might prove cumbersome and complicated in that major modifications to plumbing and wiring of the lab might be necessary (Walter, pers. com.). An alternative approach would be to make arrangements with a hospital laundry to borrow the use of some facilities for the duration of the experiments. Commercial or industrial facilities might also be considered. The advisory committee could be helpful in setting up or arranging facilities.

Preliminary studies of each variable could be used to choose the conditions that deserve further attention. Further studies must adequately show the amount of microbial kill achieved under each set of conditions. Enough trials must be conducted to allow statistical analysis.

2) Tests on naturally soiled linens

Task: The second stage of this task should be to launder naturally soiled linens under those conditions determined in the first stage to produce acceptable degrees of microbial destruction. Just what degree of microbial kill is considered acceptable must be decided by evaluation of the results of the first stage by the researchers involved and the members of the advisory committee. A decision must be reached by the group as to whether any losses in microbial kill at temperatures lower than 160°F represent an unsatisfactory compromise between energy savings and sanitary linens. Linens included in this study should include those from isolation areas, and those in regular use. This stage is needed to prove that the results from seeded swatches can be applied to normal linens, including isolation linens. Linens need to be divided randomly into two groups for each trial. One group will function as a control, and would be laundered with a standard formula (160°F, no changes from those currently used in hospitals). The other group would represent the experimental group, with changes in formulae as desired. Those conditions that proved to be microbially unacceptable during evaluation of the first stage results need not be considered in this stage of the experiments.

Energy use estimates need to be made for all sets of conditions tested. Either calculated, or actual, values would suffice for the purposes of this study.

Evaluation of Cleaning Ability (for conditions deemed to be promising in Part B).

Another reason attributed to the use of 160^{O}F water in the wash cycle is the need for adequate cleaning and stain removal. Less energy intensive conditions might be capable of adequate cleaning of hospital linens, and also provide sanitation levels that are considered acceptable.

Objective: To evaluate cleaning capabilities of laundry formulae which provide acceptable sanitation levels.

Task: These trials should be conducted on normally soiled linens, with as many commonly encountered stains as possible. Only those conditions found acceptable in previous trials need be considered. Evaluation of the cleaning process should include: overall impression; whiteness retention; soil removal; stain removal; and tensile strength loss.

Linens should be washed as in previous trials. Drying and ironing might facilitate evaluation of the linens. Whiteness retention, soil removal, and tensile strength loss can be measured by accepted methods in the literature (e.g. Loeb and Pollard, 1970). Overall impression and stain removal can be subjectively determined. Information obtained from these experiments should demonstrate any loss in quality of the finished linens that may result when washed at conditions different than those used currently.

C) Evaluation of contributory lethal effects of additional laundry processes

Several published reports have alluded to the bactericidal effects of drying and ironing. Few attempts have been made to examine systematically the degree of kill obtained in drying or ironing. Since essentially all linens in the hospital laundry are dried and most are ironed, an examination of the bactericidal properties of these processes could demonstrate their usefulness in destroying organisms. If the bactericidal effects of drying and ironing proved to be substantial, the use of lower temperature wash water might be possible for all linens that are dried or ironed, regardless of the results obtained from washing alone.

Objective: To evaluate the bactericidal properties of drying and ironing as used in the hospital laundry.

Task: These experiments could be conducted at the same time as the seeded swatches are tested after laundering. Samples from all conditions tested in the laundering trials should be examined. Measurements could be made on some swatches immediately after laundering; the remaining swatches would be dried and ironed and then measured. Variables that should be examined in these processes are drying time, drying temperature, and ironer temperature. Energy use estimates are required to determine if changes in drying or ironing procedures can compensate for any loss in bactericidal action obtained in washing at temperatures less than 160°F.

Development of Sanitary Practices.

The results of all these experiments should provide enough information to define the relationship between temperature and contamination levels and to quantify the role of other factors in microbial destruction. Based on this information, a sound decision can be reached on what conditions are necessary to provide linen that is acceptable in appearance and safe for patients. Revision of current standards may or may not be justified on the basis of the results of the research program. However, maintenance of a conservative standard to compensate for correctable shortcomings in the laundry process should not be considered as an alternative if revision can be justified. For this reason, it is recommended that a set of acceptable sanitary practices for hospital laundry facilities be developed and adopted. Compliance could be encouraged if these practices were adopted as guidelines by an agency such as the Joint Commission on Accreditation of Hospitals or the National Sanitation Foundation. These practices could be an extension of those presented earlier in this report, or could be drawn from references on the subject. Possible inclusions are guidelines on the size of wash loads and the use of recording thermometers in the washers to show that sanitizing conditions have been met. A minimum tolerance standard or maximum allowable contamination level, such as suggested by Wetzler et al (1971), could be included in these guidelines. A minimum tolerance standard would serve best as an index of quality control in the laundry, although it could also serve for enforcement purposes if desired. A destructive sampling technique could be used without destroying good linen by using one large sheet or swatch for all tests, and cutting off samples after the sheet is laundered with a normal load. An equilibrium of soil and microorganisms is reached between wash water and fabrics; if there are any surviving microbes, they will be detected in the fabric sample (Wetzler, pers. comm.)

Performance of the Research Program.

The first choice to conduct this research program would be a university setting. A university would provide the research program with personnel skilled and knowledgeable in those areas that are essential to this research program. Industries may also have the personnel, but may not be able or willing to make the required commitment of time, space, and people. A university laboratory is accustomed to, and capable of, making such large commitments, as long as sufficient funding exists to conduct the research.

Funding for this research program could come from any of several sources. The Department of Energy (DOE), and Department of Health, Education, and Welfare (DHEW), are two federal agencies that might be suitable. DOE might have a greater interest in that revision of the existing standards could result in significant energy savings. DHEW's concern is from a public health viewpoint, and a revised standard would need to be changed through them.

The National Sanitation Foundation might be able to sponsor this research program. They would need to receive funding from other sources to do this, but their role as a sponsor could facilitate distribution and/or acceptance of a revised standard. In the past, NSF has received funds from outside sources, and sponsored work on microorganisms in continuous cloth towels (Wetzler, per. comm.). Such an arrangement might prove to be workable in this case as well. NSF's association with this research program could prove quite valuable in obtaining support for any proposed revised standard.

It is estimated that this project would take from one to two years of work to answer satisfactorily the problems above. The largest expenditure would be in salaries for the principal investigator, plus at least two technical assistants. Money would also need to be allocated for supplies including detergents, bleaches, lab supplies and a large supply of linens. A conservative cost estimate is \$100,000 to \$150,000 for two years.

Implementation.

In order to effect the implementation of a revised standard for laundry water temperature, there must be a consensus among experts and practitioners regarding the cleaning and sanitizing ability present at the suggested lower temperature. Opinions concerning the results of a research program should be solicited from established microbiologists, especially those with experience with laundry projects. Laundry managers should be consulted for opinions on the practical aspects of implementation. State health departments should also be asked to comment on a proposed standard. Infection control personnel in the hospital should also be addressed on the revised standard. Finally, JCAH should be given the opportunity to comment.

A final report should be drafted by the research team. This report should include the results of the program, plus a summary of the opinions obtained concerning a revised standard. This report should be presented to DHEW, as evidence to support or refute changing the laundry temperature standard.

Alternatives.

There might be a tendency by funding agencies to balk at providing sufficient funds to carry out a research program of the size suggested in this report. Energy savings derived from a lowering of the laundry water temperature may be considered too small to justify an expenditure of several hundred thousand dollars. If for this or other unidentified reasons, it is seen fit not to carry out a comprehensive research program, efforts should be directed at alternative means of energy conservation in the laundry. The use of heat and water reclaimer devices in the laundry can potentially save thousands of dollars in energy costs. However, the high initial cost of such devices makes them cost effective only for hospitals of 500 or more beds (Hittman Report). Heat exchangers can be cost effective for hospitals of 200 or more beds. Actual values for energy savings depend on the specific site of use, and would need to be evaluted for individual laundries.

Energy savings are possible in the hospital laundry; they can be realized through the implementation of new water temperature standards, or through the updating of equipment and formulae. The long term savings must be considered in determining the feasibility of funding projects related to energy savings in the hospital laundry.

TABLE 10. PROPOSED RESEARCH ACTIVITIES. TIME AND COST ESTIMATES

	Activity	Time Estimate	Cost
1.	Formation of Advisory Committee	1st 3 months	$ 2,400
2.	Survey of Microbial Contamination levels at 160°F	3 months	21,000
3.	Vary Wash Cycle Conditions - Microbial Destruction and Cleansing Evaluation	6 months	42,000
4.	Evaluation of Cidal Effects of Additional Laundry Processes	3 months	21,000
5.	Final Report Preparation	3 months	2,400
	TOTAL	1½ years	$88,800

Cost estimates assume salary and fringe benefits for principle investigator and two technicians. Also included is approximately $400 per month for supplies.

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Appendix

SECTION 5. MICROBIOLOGICAL EVALUATION PROCEDURES

5.00 GENERAL: Microbiological evaluation procedures shall be as specified in Item 5.01. Variations therein, or alternates thereto, may be employed provided they are capable of being at least equal to those specified.

5.01 PROCEDURE:

5.011 Using sterile scissors cut a 36 square inch swatch from the towel sample. Weigh it, and shred the swatch into a sterile container, add 500 mls of diluent and place on a paint can shaker for 10 minutes. As an alternate, the aseptically shreded towel sample may be processed in a sterile blender. This may be done either as a single or as a multiple process. It is imperative that 36 square inches of towel sample be processed.

5.012 From the 500 mls of "rinse extracted" or macerated sample, transfer 11 ml ± 1 ml to duplicate sterile screw-capped tubes. Heat shock one tube at 80° C for 10 minutes. Make decimal dilutions from both tubes in a suitable neutralizing buffer system.

5.013 From the decimal dilutions series, make pour plates in duplicate, using Trypticase Soy Agar (BBL or equivalent) with 0.5 percent yeast extract. Make streak plates in duplicate by placing 0.1 ml of the decimal dilutions onto Blood Agar plates (TSA/YE + 5 percent blood) and spreading with a sterile bent glass rod.

5.014 Incubate all plates at 35° C for 12 hours and then at room temperature for 30-48 hours.

5.015 Record and calculate all data in units per ml; units per square inch, or units per 0.1 gm. The data are tabulated and/or graphed for a standardized report form.

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